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A Review on Experimental Investigation of Natural Convection Heat Transfer with a Special V Fin Array

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Abstract— Natural convection from vertical surfaces with large surface element is encountered in several technological applications of particular interest of heat dissipation from electronic circuit. Natural convection represents an inherently reliable cooling process. Because of boundary layer development, the tall vertical fins restrict the heat transfer enhancement. . This heat transfer enhancing technique was investigated for natural convection adjacent to a vertical heated plate with a multiple v- type partition plates (fins) in ambient air surrounding. In order to enhance the heat transfer, V-shaped partition plates (fins) with edges faced upstream were attached to the two identical vertical plates. The V-type partition plates with two different heights were tried. The heat transfer in the downstream region of the partition plate is markedly enhanced when the plate height exceeds certain critical values because of the inflows of the low temperature fluid into the separation region. It was observed that among the three different fin array configurations on vertical heated plate, V-type fin array design performs better than rectangular vertical fin array and V-fin array with bottom spacing design. The performance was observed to improve further, with increase in the height of the V-plates.

Key words: V-shaped partition plates, heat transfer enhancing technique, heat transfer enhancing

I. INTRODUCTION

When available surface is found inadequate to transfer required quantity of heat with available temperature gradient, fins are used. Rate of heat dissipation from a fin configuration by convection heat transfer depends on the heat transfer coefficient and the surface area of the fins. The surface area of the fins can also be increased by adding more fins to the base material in order to increase the total heat transfer from the fins. But the number of the fins should be optimized because it should be noted that adding more fins also decreases the distance between the adjacent fins. Using fins is one of the cheapest and easiest ways to dissipate unwanted heat and it has been commonly used for many engineering applications successfully. Fins are used to enhance convective heat transfer in a wide range of engineering applications, and offer a practical means for achieving a large total heat transfer surface area without the use of an excessive amount of primary surface area. Fins are commonly applied for heat management in electrical appliances such as computer power supplies or substation transformers. Rectangular fins are the most popular type of fins because of their low production costs and high effectiveness. Configuration of all fins protruding from their bases is popular because they offer economical and trouble free solution to the problem. Natural convection heat transfer is augmented by provision of rectangular fins on horizontal or vertical surfaces in many electrical and electronic appliances. Because of reduction in surface area available for heat dissipation and low heat transfer coefficient optimization of fin, geometry becomes very important in natural convection heat transfer. Now a days in electronic industries microminiaturization of electronic packages are in trend. The thermal design problem is recognized as one of the factors limiting achievement of higher packaging densities. Natural convection occurs due to temperature difference which produces the density difference. To optimize the fin geometry some portion of this stagnant zone is removed in various shapes and sizes and its effect on other parameters are studied in this investigation. Some of the material from that central portion is removed, and is added at the place where greater fresh air comes in the contact of the fin surface, it would increase the overall heat transfer enhancing technique ‘h’. In present study the fin flats are modified by removing the central fin portion.

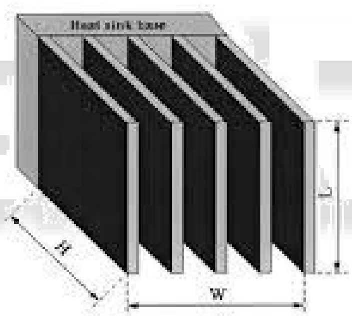

Fig. 1: Rectangular Fins (view)

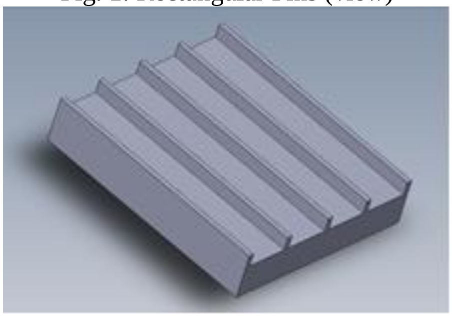

Fig. 2: General Base Structure

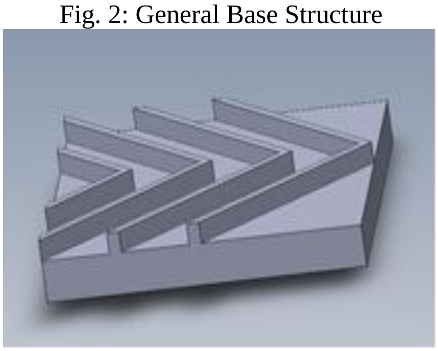

Fig. 3: V Fins (Apex on RHS)

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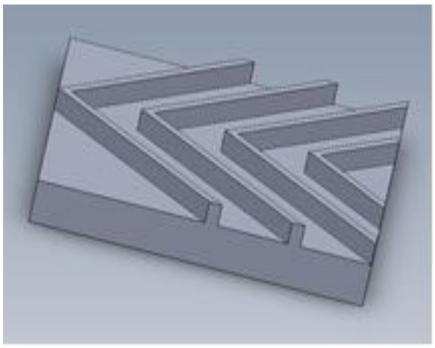

Fig. 4: V Fins (Apex on LHS)

Fig. 5: V Fins (Apex facing downwards)

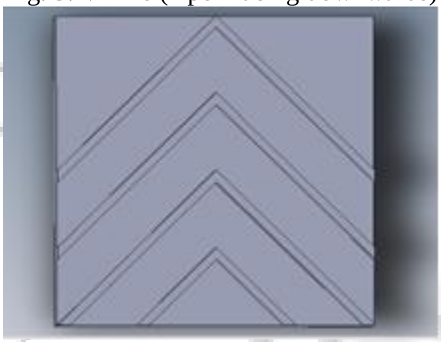

Fig. 6: V Fins (Apex facing upwards)

II. LITERATURE REVIEW

The work by **Prasolov et al. (1961), Heya et al. (1982), Bhavnani et al.(1990)** suggested that the roughness elements whose height is less than the boundary layer thickness will have no appreciable influence on the heat transfer of natural convection and these elements will work as flow retarder rather than the heat transfer promoter.[1-3]

In order to dispose of the boundary layer restrictions and develop a compact high-performance heat transfer plate, some investigators have developed horizontal partition plate and V-shaped plates. Firstly, **Misumi *et al.* (1990)** found that the heat transfer in the downstream region of the partition plate is markedly enhanced when the plate height exceeds certain critical values because of the inflow of the low temperature fluid into the separation region. For vertical plate with V-shaped fins, the heat transfer coefficient obtained was 40% higher than the conventional fins. Further, it was observed that the ratio of the heat transfer enhancement exceeds the ratio of the surface enlargement; moreover the enhancement obtained for horizontal partition plate and vertical fin was less than V-plate [4].

Baskaya et al. (2000) carried out parametric study of natural convection heat transfer from the horizontal rectangular fin arrays. They investigated the effects of a wide range of geometrical parameters like fin spacing, fin height, fin length and temperature difference between fin and surroundings, to the heat transfer from horizontal fin arrays. However, no clear conclusions were drawn due to the various parameters involved. Finally they concluded that, it is not possible to obtain optimum performance in terms of overall heat transfer by only concentrating on one or two parameters. The interactions among all the design parameters must be considered. This study has shown that each of the variables produces an effect on the overall heat transfer. As a whole, it can be concluded that the overall heat transfer is enhanced with the increase in the height (H), of the fin and decrease in the length (L) of the fin [5].

Sane et al.(2008) established a match between the experimental results and the results obtained by using CFD software for a horizontal rectangular notched fin arrays dissipating heat by natural convection Both, the flow patterns as well as the trend of heat transfer coefficient are found to be within 5% range. It is observed that total heat flux as well as the heat transfer coefficient increases as the notch depth increases.

As the area removed from the fin is compensated at the air entry ends of the fin it provides a chance to get greater amount of fresh cold air (getting sucked into the array through a single chimney pattern) to come in contact with hot fin surface. As the air moves inwards along the chimney profile, it gets heated and the temperature difference between the fin and entering air decreases. This area of fin (near its lengthwise centre) thus becomes relatively less useful for heat transfer. Now, when this area is re-moved and added at a place where it is more useful for heat transfer, the heat transfer increases and so does the convective heat transfer coefficient. CFD analysis was completed for two cases viz (a) Unnotched fin Array and (b) Fin Array with Notch of 20 %and 40% area removed. This analysis reveals that the single chimney flow pattern is maintained for both the cases, the performance of notched array is better by up to 41.82% [6].

Edlabadkar et.al.(2008) did experimental investigation on single V-type partition plate with different included angles, in air as ambience in the laminar air flow over a vertical base plate with length 0.3m, width 0.3m, and V shape fin (the fin limb length is 0.15m and width 0.05m) attached to it was numerically captured using Computational Fluid Dynamics (CFD) software of FLUENT with laminar viscous model. Computations were performed for the geometrical configurations with fin included angles 90°, 120° and 60°, for equal base and fin areas dissipating heat under natural convection condition for temperature difference θ, varying from 30°C to 150°C. The results show that the 90° V fin gives least resistance to flow separation in the upstream region and most effective high heat transfer region in the downstream region of the base plate. It was observed that among the three V-type partition plates, the maximum increase in heat transfer enhancement is 12% for 90° V-partition plates as compared to vertical partition plate and 15.27% as compared to horizontal partition plate [7].

Wankhede et al. (2008) developed an experimental setup to carry out the investigation on horizontal rectangular fin array with and without inverted notch under natural and forced convections. The objective of the work was to determine the heat transfer characteristics experimentally, and further to find out the enhancement in heat transfer in

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the case of notched fin arrays over normal fin arrays, and analyzed the effect of different parameters like length, height, spacing of fins on heat transfer coefficient (h).

It is concluded that, the values of average heat transfer coefficient (h_a) increases as percentage of area removed increases near about 30 to 70% rise is achieved as compared to normal fin array. The value of base heat transfer coefficient (h_b) increases as fin spacing decreases reaches maximum, giving optimum spacing and again decreases. For very less fin spacing the values of both ha and hb are significantly less. The value of average Nusselt number (Nu) increases with increase in fin spacing. The value of base Nusselt number (Nub) increases as fin spacing decreases; it reaches to its maximum and again decreases[8].

Sable et al.(2010) investigated heat transfer enhancing technique for natural convection adjacent to a vertical heated plate with a multiple V- type partition plates (fins) in ambient air surrounding.

They concluded that as compared to conventional vertical fins, the V-type partition plates work not only as extended surface but also as flow turbulator. The tall vertical fin array restricts the heat transfer enhancement from tall vertical base plate. This is because of the boundary layer thickening and subsequent interference developed over the height. The experiments were conducted with the width of the partition plate (fin height) varying from 20mm to 38mm for a plane vertical plate, vertical plate with vertical fins, vertical plate [9].

Barhatte et al. (2012) did the study on heat transfer rate through different types of notches in the fin. He used different notches such as rectangular, circular, triangular and trapezoidal. He compare without notch and notch fin array by supplying different heat inputs. The dimensions of fin were fixed. They concluded that more heat is transfer through triangular notch fin [10].

Kharche et al. (2012) used fin with notch and without notch of copper as a fin material on vertical heated plate for the experimental work. The shape of the notch was rectangular. They compared the effect of heat transfer coefficient for notch and without notch fins.

From the experimental study it was found that the heat transfer rate in notched fins was more than the unnotched fins. The average heat transfer coefficient for without notched fin was 8.3887 W/m^2K and for 20% notched fins it was 9.8139W/m^2K. Also the copper gives more heat transfer rate than aluminum plate. In order to dispose of the boundary layer restrictions and develop a compact high-performance heat transfer plate, some investigators have developed horizontal partition plate and V - shaped plates [11].

III. Concluding Remarks

Many previous researchers investigated natural convection heat transfer from the extended surfaces.

These studies are motivated by the fact that the heat transfer rate from the extended surfaces differs greatly from that from the base surfaces.

The vertical fins are inapplicable to the heat transfer enhancement of a tall vertical plate. This is because the boundary layer developed over the tall plate becomes very thick. To obtain an appreciable improvement of the heat transfer, the fin height must be greater than the boundary layer thickness. Obviously such high fins are not practical.

As compared to conventional vertical fins, the V-type partition plates work not only as extended surface but also as flow turbulator.

For vertical plate with V-shaped fins, the heat transfer coefficient obtained was 40% higher than the conventional fins. Further, it was observed that the ratio of the heat transfer enhancement exceeds the ratio of the surface enlargement; moreover the enhancement obtained for horizontal partition plate and vertical fin was less than V-plate.

For horizontal V-shaped fin array with various included angle, it was concluded that the maximum convective average heat transfer coefficient is obtained for 60^0 V-fin array.

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